

UK Centre for Astrobiology

A proposal for affiliation to the NAI

September 13, 2012

Charles Cockell
University of Edinburgh

University of Edinburgh
Founded in 1583 as a College of Law

Approximately 30,000 students covering all subjects
First UK university to create a Chair in Astrobiology



Edinburgh has critical mass in a number of areas



School of Physics & Astronomy

School of Biological Sciences

School of GeoSciences



Research at Edinburgh

- **Geomicrobiology (C. Cockell)**
- **Planet formation (K. Rice)**
- **Synthetic Biology (T. Le Bihan)**
- **Numerical Astrobiology and SETI (D. Forgan)**
- **Protein folding (C. MacPhee)**

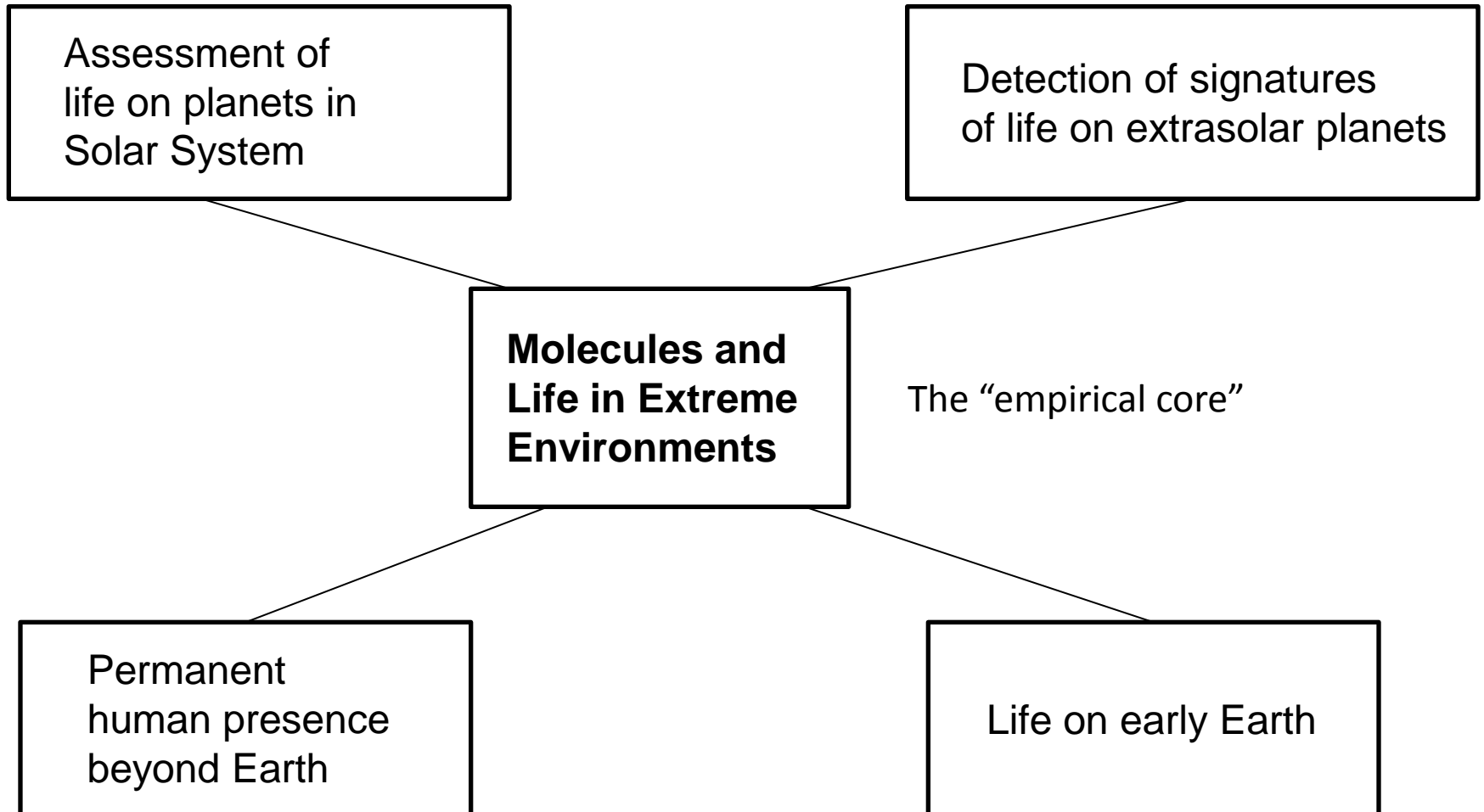


**UK Centre for
Astrobiology**

The mission of the UK Centre for Astrobiology is to advance our understanding of molecules and life in extreme environments on the Earth and beyond. It does this by a combination of theoretical, laboratory, field and mission approaches. We apply this knowledge to improving the quality of life on Earth and developing space exploration as two mutually enhancing objectives.

www.astrobiology.ac.uk

UKCA : Areas of Investigation



The UK Centre for Astrobiology is:

- *A national* virtual Centre
- An initiative of the Scottish Universities Physics Alliance
- Based at Edinburgh
- Operated through an affiliation of 'nodes'
- Focused on the study of molecules and life in extreme environments
- Mainly lab and theory based, but with mission objectives where possible



UK Centre for
Astrobiology

Research Affiliate Nodes (RANs)



Imperial College
London



Cranfield
UNIVERSITY



University of
Kent



Areas of research activity of affiliate nodes

	Areas of astrobiology
Edinburgh	Geomicrobiology, Synthetic Biology, Extreme conditions (pressure)
Kent	Impact science
Cranfield	Sensors, life in cold environments, space technology
Bradford	Raman spectroscopy
Leeds	Origin of life, life in cold environments
Aberdeen	Organic molecules, organic geochemistry
Glasgow	Geobiology, meteoritics
Leicester	Space technology (XRD, Raman etc)
Birkbeck	Lunar science, life in cold environments
Nottingham	Space biomedicine
East Anglia	Extrasolar planets and their detectability
Imperial	Organic geochemistry
Open	Mars exploration, space science
Oxford	Space instrumentation
Bath	Extremophiles
Bristol	Life in cold environments

	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6	Goal 7
Edinburgh	X	X		X	X	X	X
Kent		X	X	X	X		X
Cranfield		X			X	X	X
Bradford		X		X	X		X
Leeds	X		X				X
Aberdeen		X		X	X	X	X
Glasgow	X	X			X		X
Leicester	X	X			X	X	X
Birkbeck	X	X			X	X	X
Nottingham	X					X	
East Anglia	X		X	X	X		X
Imperial	X	X	X	X	X		X
Open	X	X		X	X	X	X
Oxford	X	X			X		X
Bath	X				X		X
Bristol	X	X		X	X		X

University of Edinburgh (UKCA) and affiliate Universities of UKCA and their relationship to NASA Astrobiology Roadmap (Goal 1: Habitable planets; Goal 2: Life in our Solar System; Goal 3: Origins of Life; Goal 4: Earth's early biosphere and its environment; Goal 5: Evolution, environment and limits of life; Goal 6: Life's future beyond Earth; Goal 7: Signatures of Life).

Management: UKCA Committee

Charles Cockell (Edinburgh), Chair

Cait MacPhee (Edinburgh)

Ken Rice (Edinburgh)

Paul Attfield (Edinburgh)

Laura Sganola (Edinburgh)

John Loveday (Edinburgh)

Blanca Antizar-Ladislao (Edinburgh)

John Raven (Dundee)

Jane Greaves (St Andrews)

John Parnell (Aberdeen)

Martin Lee (Glasgow)

Vern Pheonix (Glasgow)

Sophie Nixon (Edinburgh)

Casey Bryce (Edinburgh)



Management philosophy:

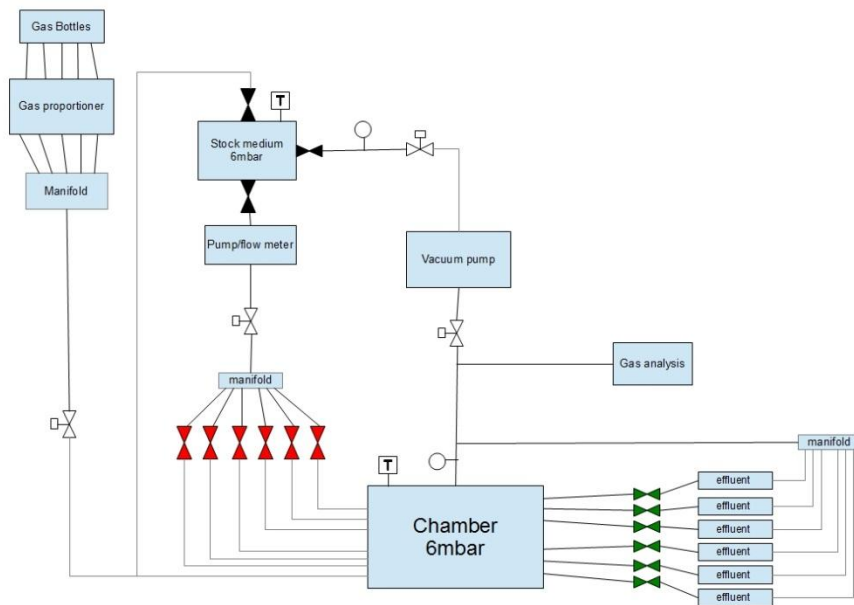
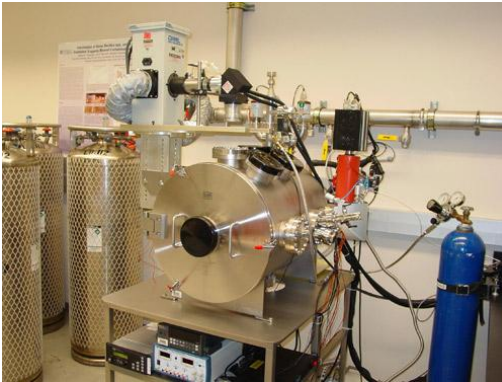
Create and manage facilities of use to the astrobiology community. Otherwise operate virtually.

Purpose of Edinburgh : Manage centre and oversee facilities

Purpose of Research Affiliate Nodes: Create a consolidated UK Centre that strengthens the profile of astrobiology, without compromising independence of affiliates.

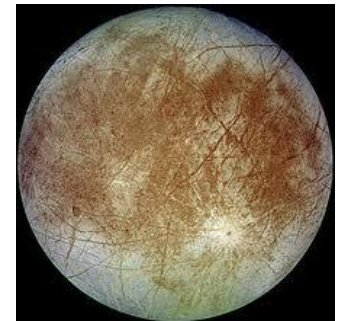
Planetary Simulation Facilities: Phase I

- Creating a simulation chamber to allow us to look at water-rock interactions and geochemistry with the biological component
- Examine habitability of extraterrestrial environments



Planetary Simulation Facilities: Phase 2

- Creating a simulation chamber to allow us to look at water-rock interactions and geochemistry with the biological component under high pressure conditions
- Operating at 2-3 kbar
- Allow for the study of geochemistry and biology in the deep subsurface of other planetary bodies





UK Centre for
Astrobiology

ISAL

International Subsurface Astrobiology Laboratory

*A new facility for the study of deep
subsurface life and assisting the human
exploration of other worlds*

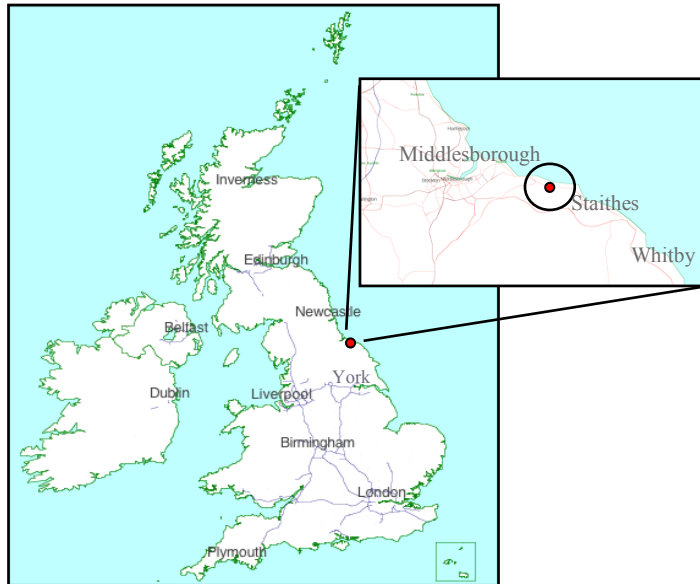


Boulby Mine

A working potash and rock-salt mine on the North East of England.

Operated by Cleveland Potash Ltd.

Major local employer - ~1000 direct and 4000 indirect employment.



Potash



View from Staithes

Deepest mine in Britain – 1100m deep (2805mwe) – Cosmic ray muon flux reduced by 10^6

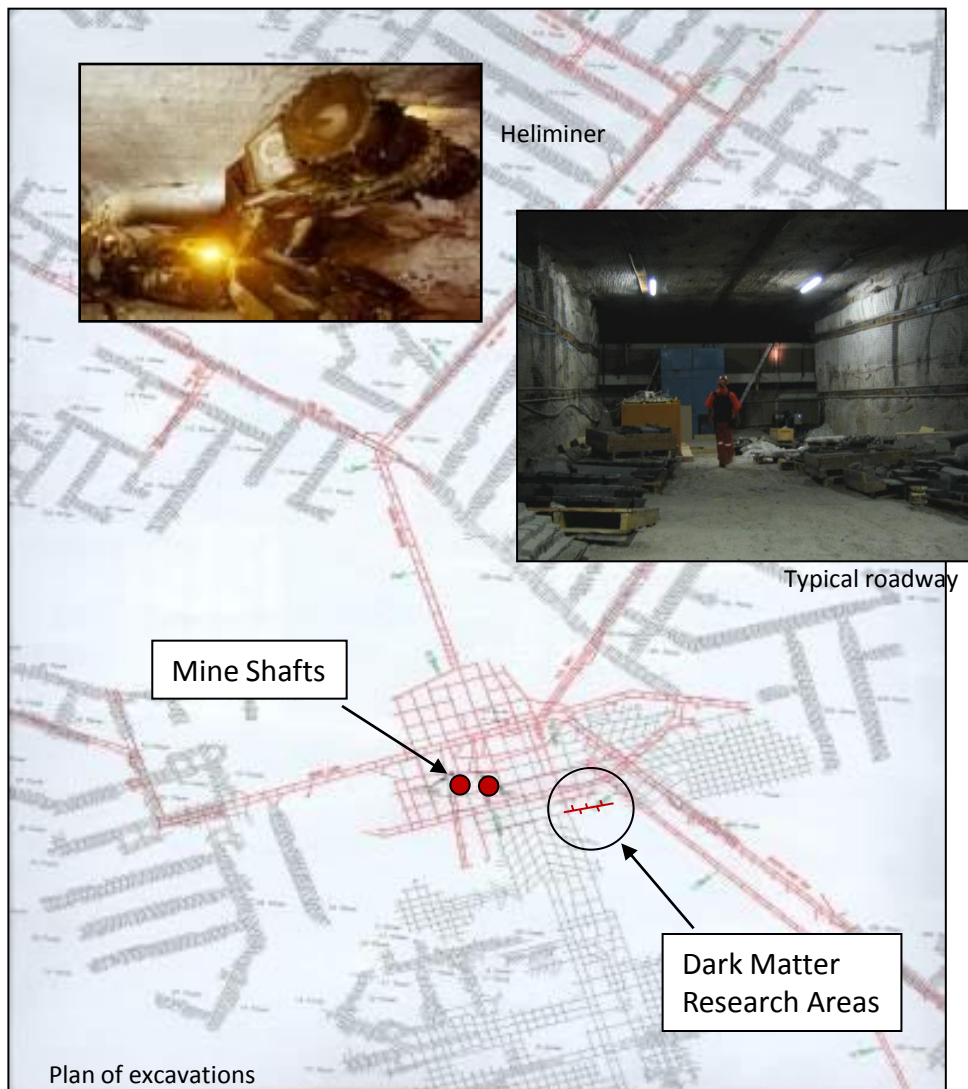
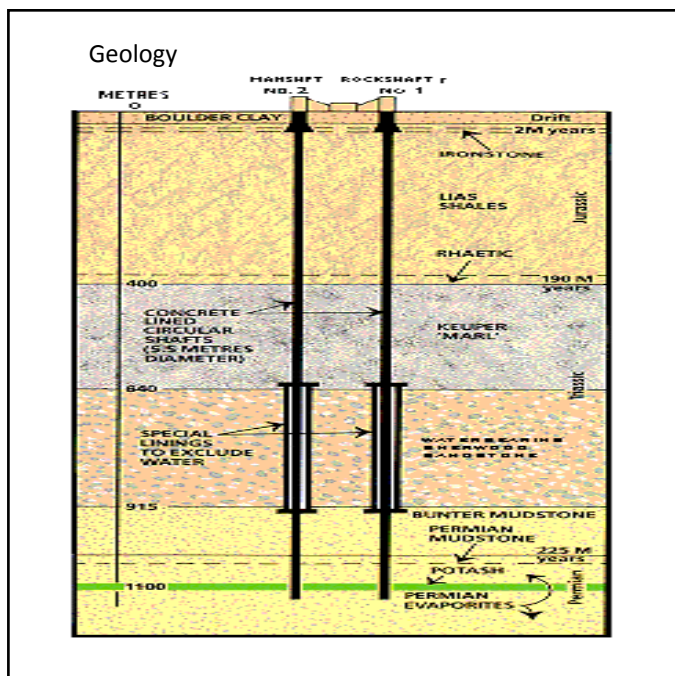


Boulby Mine

Over 40 kms of tunnel mined each year
(now >1,000kms in total)

Long lived roadways cut in salt (NaCl) –
giving access to potash (KCl) levels just
above

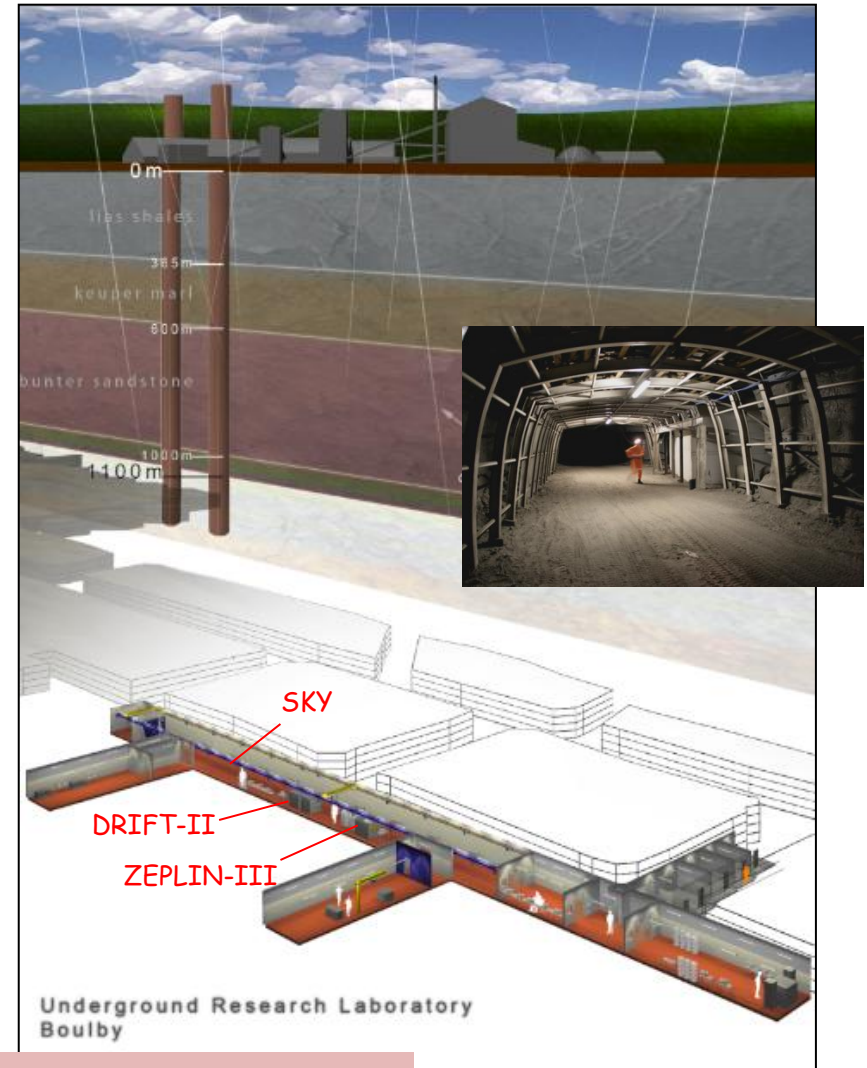
Boulby salt is very low in natural
radioactive backgrounds (U, Th, Rn)



Boulby Science facilities

‘JIF’ Science Facilities (opened 2003).

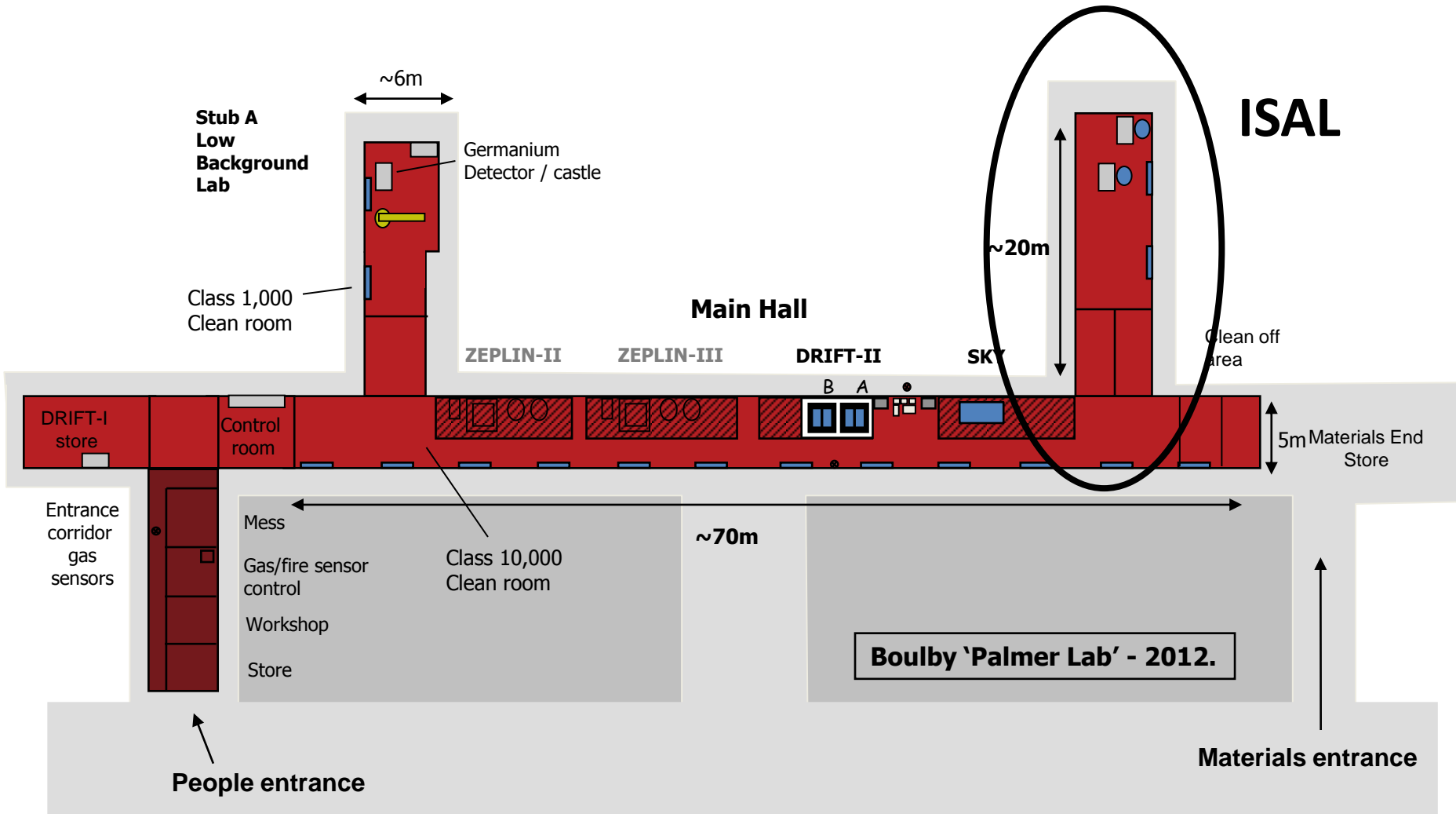
- ‘Palmer Lab’: a 100+m, fully equipped underground lab. Power, internet and telephone communications, lifting, air conditioning / filtration, clean room.
- ‘John Barton’ surface facility: Workshop, facility monitoring, office and administration, PPE, storage, chemistry lab, changing rooms.



A **QUIET** place in the Universe



Palmer Lab – 2012





ISAL



ISAL

Existing Deep Subsurface Laboratories

Laboratory	Depth	Substrate
International Subsurface Astrobiology Laboratory, Yorkshire, UK	1.1 km	Permian salt
Sudbury Neutrino Observatory, Ontario	2.07 km	Norite granite
Laboratoire Souterrain de Modane, France	1.75 km	Schistes lustrés
Gran Sasso National Laboratory, Italy	1.4 km	Dolomite and limestone
Äspö Hard Rock Laboratory, Sweden	500 m	Diorite, granite and greenstone
HADES Laboratory, Belgium	224 m	Boom clay

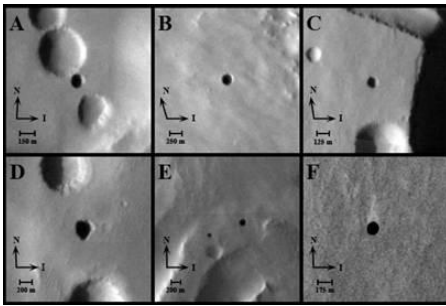


Science at ISAL:

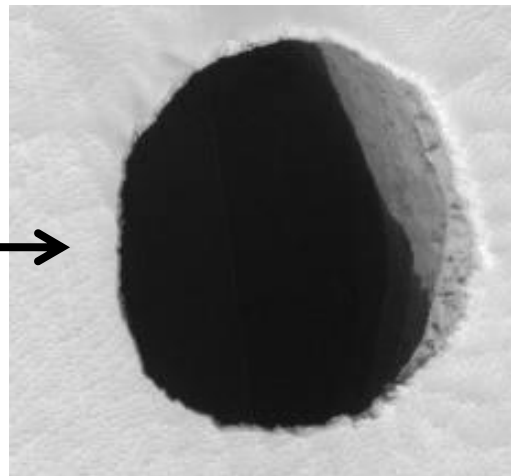
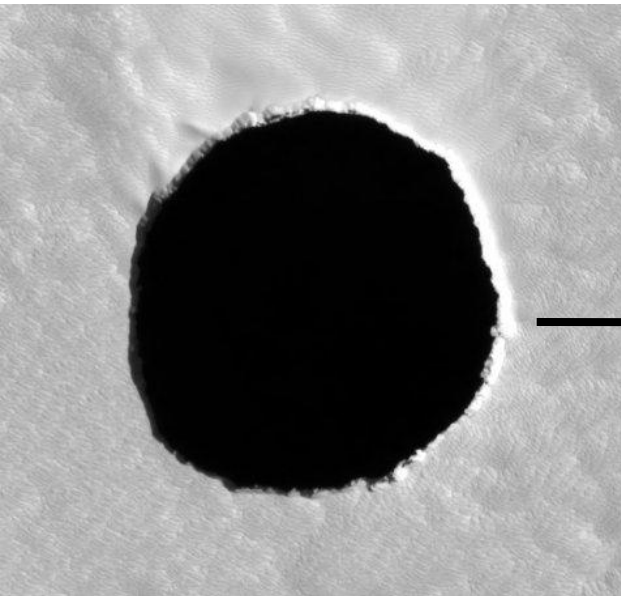
- Deep subsurface microbiology
- Deep subsurface microbiology of halite
- Deep subsurface biogeochemistry
- Gas production in deep subsurface
- Biology in a radiation-reduced environment

Boulby as an analogue environment

Subsurface environments teach us how to explore (and exploit caves on the moon and Mars)



Caves on Mars





**UK Centre for
Astrobiology**

Boulby and Instrumentation for Earth and Space Exploration



➤ A major challenge in space exploration is miniaturising instrumentation because of the mass and energy cost of transporting materials into space. This is true for both robotic and human exploration. This equipment is also needed on Earth.

ISAL will allow us to test life detection and general analytical technologies (e.g. IR and Raman spectroscopy, portable XRD and XRF etc) that could be used in space exploration missions and optimise design.

➤ **ISAL will also allow us to validate these technologies for use in extreme environments on the Earth and in geological repositories.**

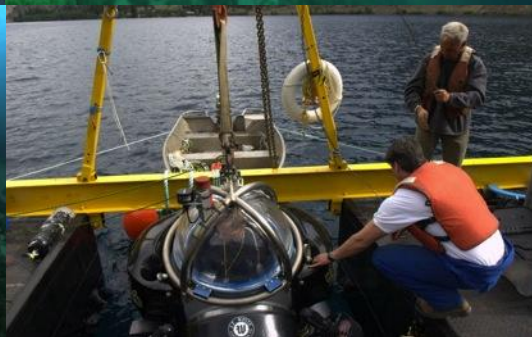


ISAL will provide a new capability to develop instrumentation for extremes environments on the Earth and in space

Field Analog Missions – the NASA link



Lim et al 2010, Planetary Space Science



Exploration Concepts for Field Science on Earth and Beyond – The Pavilion Lake Research Project (PLRP)



Team NASA



Andrew Abercromby



Expertise: EVA Physiology and Operations, Biomechanics, Research Methods
Affiliation: NASA Johnson Space Center
Certification/Education:
 Ph.D. (Biomechanics & Motor Control) University of Houston, 2006
 M.Eng. (Mechanical Engineering), University of Edinburgh, 2002
[Full Biography »](#)

Jennifer F. Biddle
 Researcher



Expertise: Microbial Ecology
Affiliation: University of Delaware
Certification/Education:
 PhD, Biochemistry and Molecular Biology, Pennsylvania State University, 2006
 BS, Biotechnology, Rutgers University, 1999
[Full Biography »](#)

David Lees



Expertise: Robotics, Computer/Human Interaction
Affiliation: NASA Ames/CMU
Certification/Education:
 Ph.D. (Mechanical Engineering), Stanford University
 B.S. EE&CS, Johns Hopkins University
[Full Biography »](#)

Lauren Rush



Expertise: Operations and Planning Engineer
Affiliation: NASA
Certification/Education:
 BS Industrial Engineering, Purdue University
[Full Biography »](#)

Mike Gernhardt



Expertise: NASA Astronaut, Manager of Environmental Physiology Laboratory and Principle Investigator of Prebreath Reduction Program, Johnson Space Center
Affiliation: NASA
Certification/Education:
 Ph.D. Bioengineering, University of Pennsylvania
 M.A.Sc. Bioengineering, University of Pennsylvania
 B.Sc. Physics, Vanderbilt University
[Full Biography »](#)

Michael Downs
 Comms Team



Expertise: Communications and Logistics
Affiliation: NASA Kennedy Space Center
Certification/Education:
 Advanced Project Engineer for KSC IT Application Services Division
 B.S. Computer Science, University of Central Florida
 Cisco Certified Network Engineer
 NAUI Open Water Diver
[Full Biography »](#)

Marc A. Seibert



Expertise: Space Communications, Networking and Space Network Emulation
Affiliation: NASA
Certification/Education:
 MSEE, Case Western Reserve University (Space Communications)
 BEEE, Michigan State University (Digital Communications)
[Full Biography »](#)

Bill Dearing
 Communication and Video Systems



Expertise: Telescience and Network Engineering
Affiliation: Kennedy Space Center, FL
Certification/Education:
 B.S. (Chemical Engineering) Tennessee Technological University
[Full Biography »](#)

Margarita "Mars" Marinova
 [



Expertise: Planetary Surfaces
Affiliation: NASA Ames Research Center - Space Sciences Division; BAER Institute
Certification/Education:
 B.Sc. - Aeronautics and Astronautics, MIT
 M.Sc. - Planetary Science, Caltech
 Ph.D. - Planetary Science, Caltech
[Full Biography »](#)

Christopher McKay



Expertise: Planetary Geologist
Affiliation: Space Science Division - NASA Ames Research Center
Certification/Education:
 Ph.D.
[Full Biography »](#)

Tamar Cohen



Expertise: Software Development, Computer / Human Interaction
Affiliation: NASA Ames Research Center, Stinger Ghaffarian Technologies Inc.
Certification/Education:
 IM.A. Visual Information Technology, George Mason University
 B.S. Computer Science, Cornell University
[Full Biography »](#)

Matthew Deans



Expertise: Robotics, Mapping, Geoinformatics
Affiliation: NASA Ames Research Center
Certification/Education:
 Ph.D. in Robotics, Carnegie Mellon University's Robotics Institute
[Full Biography »](#)

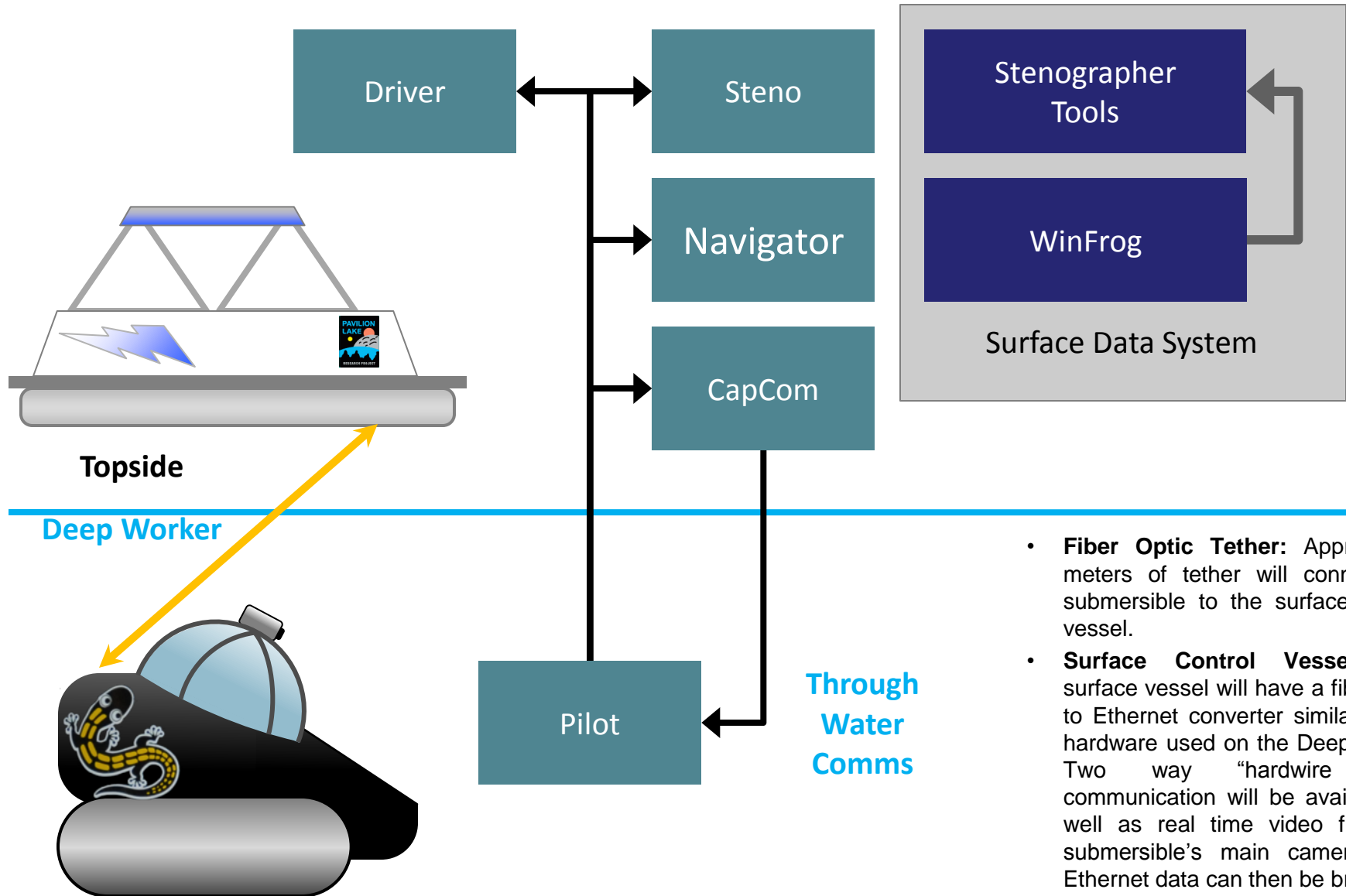
Darlene Lim



Expertise: Limnology
Affiliation: NASA Ames Research Center
Certification/Education:
 PhD Geobiology, University of Toronto, Canada
 MSc Geobiology, University of Toronto, Canada
 BSc Biology, Queen's University, Canada
[Full Biography »](#)

- Team members have supported every major NASA field deployment including the Pavilion Lake Research Project, NEEMO, DRATs, RESOLVE and the Haughton Mars Project.
- Science, engineering and operations expertise represented
- NASA and US science participation in Boulby Mine activities will be coordinated by Darlene Lim at NASA Ames

SCIENCE SUPPORT TOOLS: PLRP Communications & xGDS configuration



- **Fiber Optic Tether:** Approx 200 meters of tether will connect the submersible to the surface control vessel.
- **Surface Control Vessel:** The surface vessel will have a fiber optic to Ethernet converter similar to the hardware used on the DeepWorker. Two way "hardwire" voice communication will be available as well as real time video from the submersible's main camera. This Ethernet data can then be broadcast wirelessly using the existing network system to the Science Back-Room.



UK Centre for
Astrobiology

Three day workshop

*Boulby/ISAL as an extraterrestrial analogue
From Outer Space to Mining*

April 22-24, 2013

*Two days of visiting the mine/discussions on the
architecture of an analogue programme*

One day workshop:

'From Outer Space to Mining'

What is the International Subsurface Astrobiology Laboratory?

- A lab facility to allow for the study of life in extreme subsurface environments, particularly salts.
- A facility to develop instrumentation and analogue exploration of extreme terrestrial and extraterrestrial environments.
- A facility to help fuel international excitement for astrobiology and the study of life in extreme environments.

Meetings

Astrobiology Society of Britain and UKCA
5th biennial conference
UK Astrobiology Conference

ASB5

“Molecules and Life in Extremes”

April 17-19, 2013
University of Edinburgh

*Preceded by opening of the UK Centre for Astrobiology
and public lecture by Chris McKay at the National Museum
Of Scotland
April 16, 2013*



UK Centre for
Astrobiology

Workshop Without Walls
February 4-5, 2013

The Present Habitability of Mars

NAI, UCLA and UKCA



UK Centre for
Astrobiology

One day symposium

*Extraterrestrial Liberty:
What is Freedom Beyond Earth?*

London, June 2013?

UKCA

British Interplanetary Society

Topics for Discussion

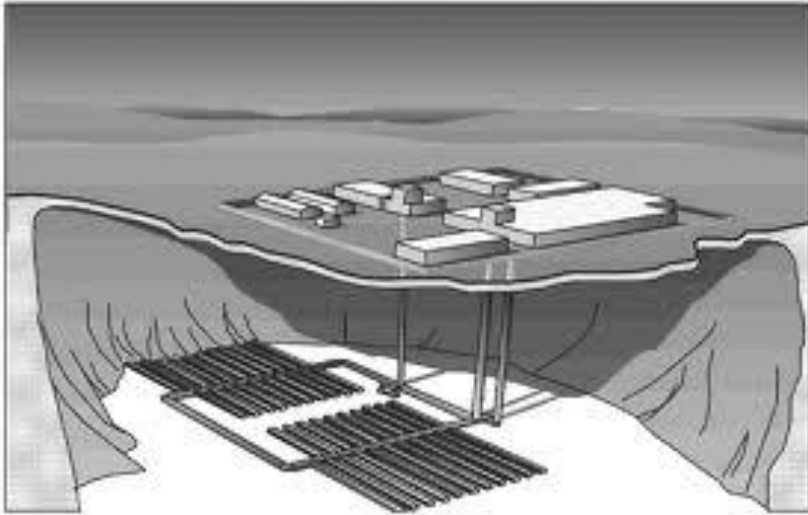
- > Liberty in moving starships
- > Liberty on planetary surface (e.g. moon and Mars)
- > The Rule of Law in space
- > Free enterprise in space - is economic liberty linked to political liberty?
- > Extraterrestrial legal systems
- > Democracy in space
- > Land ownership and freedom in space
- > Political decision making in space
- > When does a space settlement claim independence?
- > Extraterrestrial Constitutions
- > Prisons in Space

Networks

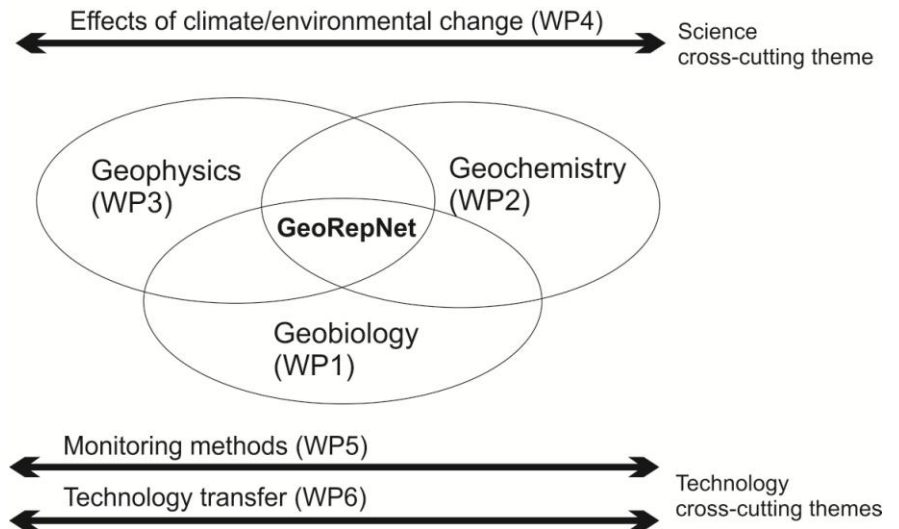
GeoRepNet

A network to consider the major geobiological, geochemical and geophysical questions in the establishment of geologic repositories.

> **With a focus on the translation of space technologies to Earth-based problems**

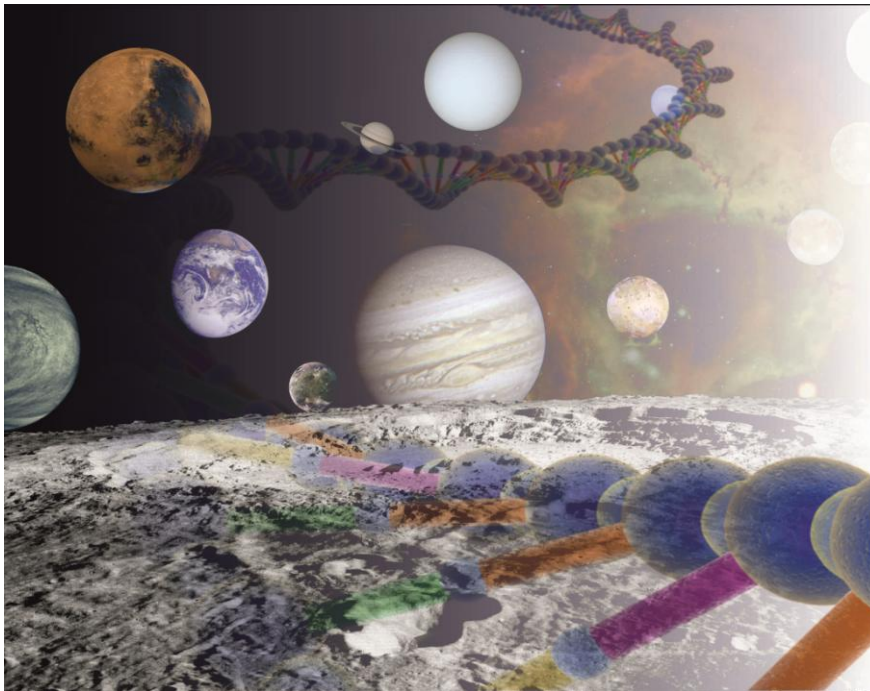


Network Structure



Outreach

Astrobiology and the Search for Extraterrestrial Life



Coursera

FROM 16 UNIVERSITIES



www.coursera.org

Starts
28 January 2013

The Course Structure

Week 1: What is life and what are the definitions of life? What do we know about the origin of life and what are the current hypotheses for how it originated on the Earth?

Week 2: What was the environment of early Earth like when life first emerged and what do we know about life on the earliest Earth? How did life evolve to cope with survival in extreme environments? What have been the major evolutionary transitions of life on the Earth?

Week 3: What are the prospects for life on other planetary bodies in our Solar System and how do we go about searching for it? What conditions are required for a planet to be habitable?

Week 4: How do we search for Earth-like planets orbiting distant stars and how would we detect life on them?

Week 5: What are the possibilities for intelligent life elsewhere? How would we deal with contact with an extraterrestrial intelligence and what would be the impact on society? Who would represent Earth?

UKCA Astrobiology Summer High School

Shetland Islands





UKCA Astrobiology Summer High School

August 2013

University of Edinburgh

Purpose:

- Give students a better idea of geology, biology, astrophysics and chemistry
- Introduce them to the excitement of astrobiology
- Show them life as a scientist
- Hear lectures, do field work and engage in real research

~10 students in first year from Shetlands for one week, then expanding



Study of life in extreme environments

The focus of the UKCA is the study of life in extreme environments. We propose hosting NAI scientists at Edinburgh and affiliate institutions (e.g. SUPA institutions, UCL, Cranfield, Bath) and *vice versa* in areas that involve the study of molecules and life under extreme environmental conditions. We also propose that scientists from the UKCA might take part in NAI field trips or field research with NAI member institutions.

Analogue research

The UKCA and many of its Research Affiliate Node universities have an interest in the study of life in environments analogous to environments on Mars and elsewhere in the Solar System (e.g. SUPA institutions (Arctic, Iceland), UCL (Iceland, African salt pans), Imperial (Atacama), Leicester (Numerous), Oxford (Morocco), Cranfield (High altitude, Iceland), Glasgow (Atacama)). Joint research trips and student exchanges could be one mechanism for enhancing the UKCA's contribution to NASA analogue field studies and the potential for NASA NAI scientists to join UK initiatives.

Use of ISAL for analogue research.

Exoplanet research

Many scientists within UKCA have an active involvement in exoplanet research (SUPA Institutions, UCL, UEA). We would be keen to investigate the possibility of exchanges or collaborative involvement in research programs involving the study of exoplanets, their habitability and detection.

Instrument development

Institutions affiliated with UKCA have an interest in instrument development including Raman, life marker chip technology, XRD, sensors and others (e.g. Leicester (XRD, Raman), Oxford (sensors), Cranfield (Life Marker Technology)). Opportunities for instrument development and mission opportunities for new instrument developments could also be areas of activity.

Synthetic biology

The UKCA has an interest in studying the biochemistry and physiology of organisms under extreme conditions and investigating their potential use in space applications. We therefore have a potential interest in collaborations with biochemistry and microbial physiologists within the NAI and teams studying synthetic biology. Edinburgh has a particularly strong synthetic biology group that could collaborate with NAI.

Outreach

Taking astrobiology to a wider audience is one major goal of any astrobiology centre. Although currently the UKCA does not have resources explicitly devoted to education and outreach, we would be interested in developing this area in combination with NAI opportunities. Potentially all of the UKCA affiliate institutions would be interested in being involved in outreach activity.



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